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Porous Pavement

Dr Pooja Gupta[1], Sumer Yadav[2], Prakshit Rajodia[3], Shubham Nair[4]
[1]Professor, [2,3,4]Student,
Department of Civil Engineering,
Poornima College of Engineering, Jaipur, India – 302022

Abstract:- Porous concrete is a special type of cementitious material consisting of a slit-graded aggregate coveredwith a thin layer of cement paste and held together by a layer of cement paste which is partially touching. Porousconcrete is concrete with an unbroken cavity that is deliberately inserted into the concrete. Permit stones are madeof asphalt, open pore foams or concrete, below which the rock deposits are present. It allows grip of rainwater and surface runoff, and store in storage and allow it to slowly penetrate into the soil below or be removed by stream tile. Fully permeable floors are installed in which all layers are permeable, and floor makers use water to collect water and minimize the adverse effects of storm water. The basic surface of both sections is open-air information that allows storm water to enter the sub-grade soil for storage. Due to the open-layer nature of the surface layer and the base layer, storm water enters the groundwater layers through layers of floor to recharge andeliminates the need for floodwater construction. When compared to conventional concrete, Porous concrete was found to have high absorptivity and was fabricated of cement, water, and coarse aggregates and is known to havethe advantages for bringing down the discharge and change the quality of water in ground for better.

Other benefits of PC include improved road safety, better off road noise, and less "heat island" effects. Low durability, maintenance due to clogging, relative weakness is some of the downsides of the porous concrete which retards its probable use in the large scale projects. Its use has been limited to parking lots, driveways, sidewalks, and roads with low traffic.

Even when space is available, collecting and treating large volumes of polluted runoff from impermeable urban highways is usu ally prohibitively costly.

As a result, traditional storm water runoff management in cities will be rendered obsolete.

Furthermore, if environmental restrictions become more rigorous in the future, many municipalities in metropolitan regions may be required or encouraged to transition from impermeable paved surfaces to permeable paved surfaces, resulting in a greener ur ban surface evolution.

Keywords:- *Stromwater runoff management, clogging, skid resistance, permeability, heat island effect.*

I. INTRODUCTION

In recent years, porous concrete pavements have gained appeal as a storm water management technology. Porous concrete pavement is a relatively recent concept in many regions of the world. Porous concrete was developed in the 1980s as an ecologically friendly material. Because of the multiple environmental benefits of reducing storm water runoff, recovering groundwater resources, and minimising water and soil pollution, it has been widely used in Japan, the United States, and Europe. Porous concrete has been used in road pavements because of its water-permeable, water-draining, and water-retaining properties [1]It's used for noise absorption and thermal insulation in a variety of applications.

In many places of the world, direct dumping of storm water r unoff caused by urban roads and highways into natural water bodies is prohibited to protect water quality.

As a result, governments, particularly transportation agencies, must employ "best management practises." (BMP).

Before releasing road runners into the wild, collect and proces s them [2].

Due to inadequate access to filthy roadways, the application o f BMPs, which are frequently used on municipal highways, is difficult and often impossible.

Even if space is available, it can be costly to collect and treat significant volumes of polluted runoff created by sealed metropolitan roadways. As a result, present approaches for managing urban runoff are neither practicable nor long-term. In addition, as environmental restrictions tighten, many cities may be compelled or encouraged to move from waterproof tiled roofs to permeable tiled roofs in order to produce a greener urban surface.

II. POROUS CONCRETE: MATERIALS, MIX DESIGN AND PROPERTIES

A. Materials

- *Aggregates*

Porous concrete is composed of aggregates of size ranging from 19- 9.5 mm. This range of aggregate size provides the porous concrete with sufficient voids in the material. In some studies, coarse aggregates of the range 9.5- 2.36 are also utilized to focus on the strength properties of the porous concrete [3]. Along with size, aggregate type also plays a vital role in showing the properties of porous concrete. From ages we were

using lime aggregate to make porous concrete but some researchers have proved that dolomitic aggregates issue high compressive strength when prepared at higher porosity levels.

- *Admixtures*

As we all know that pervious concrete is used in road pavements so it has zero slump value, which gives us the idea that some admixtures are being used in the preparation of porous concrete to make it workable without any undue increase in the water content. Several researches show that water reducing admixtures are used in porous concrete to make them workable even at low water content. Since we know that porous concrete is very harsh in nature so we require retarding admixtures to ease the field placement of the porous concrete as it may take some additional time for placement. Researchers have also recommended the use of evaporation retarders to minimize the evaporation of gauged water from the freshly laid concrete [3]. F-T durability is also checked by using Air-entraining admixtures in the preparation of porous concrete.

- *Binding material*

Ordinary Portland Cement (OPC) is usually used for the preparation of the porous concrete. The main purpose of cement material is to create edited coatings to increase the durability of the moving concrete. Additional binders such as silica fume and fly ash are also used by some researchers for the partial replacement of the OPC [3]. However, the use of this filler material in perforated concrete was observed showed different results than the conventional concrete. Rather than enhancing the properties of the porous concrete, SMCs decreased the strength of porous concrete when used beyond a threshold partial replacement. Structural and hydrological performances of the porous concrete pavements are assessed by the thickness of the cementing material coating.

B. Mix design

There is no specific mix design for the porous pavements, different researchers have given different mi designs as per theirs studies. Deo and Neithalath used absolute volume method which is the traditional method for calculating the proportion of permeable concrete mix. As we have observed, the total aggregation ranges from 1400-1800 kg / m3 with a cement to cement ratio of 4: 1-12: 1 [3]. In addition, the water-cement ratio varies in size from 0.2 to 0, 42 and lowered with conventional concrete. Nguyen et al. has developed a complex design and appropriate design for concrete mixing based on the principle of high-density paste [3]. The amount of cement screed needed to provide the required stiffness is determined by dividing it into thin layers of round rolls. Yahia and Kabagire developed a mixing rate method based on the paste size ratio (PV) and the voids in the particles (IPV).

As the conventional concrete pavement is disparate to that of porous concrete pavement so it requires especial procedure for specimen preparation. Rizvi et.al [1] conducted various researches to find a suitable compaction method to make porous concrete cylinders of 1:2 ratio (150 mm diameter and 300 mm height) for test. They conducted many researches to find the best specimen for test which closely represents the specimen which is being used in the field. A rodding and 2.5 kg standard proctor hammer was being used by them for preparing the specimen. Two layers of concrete were compacted simultaneously by a 2.5 kg standard proctor hammer to get the best specimen which resembles the field specimen. Normally it is not possible to prepare a specimen which is exactly the same as that of porous concrete but the void ratioranges within the values of porous concrete.

Bhutta and others have performed slump and flow tests on new electric concrete in their operations [1]. This test was performed to determine the performance of the new concrete. Tests for hardened aerated concrete, including compressive strength test, flexural strength test, tensile strength test, density test, porosity test and water permeability test.

Fig. 1: Test specimen of porous concrete [4]

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C. Properties

➢ *Strength properties*

Compressive, flexural and fatigue strength are some of the important properties that are studied under strength properties of a porous concrete. Many studies showed that flexural strength remain unaffected by the curing period of the porous concrete. 7 and 28 days flexural strength were seen with no difference. And it was concluded that 7 days compressive strength was approximately 70-90% of the 28 days compressive strength [5]. Polymers and micro silica were used to as modifiers to study the fatigue strength of the porous concrete. Beams were studied at various stress levels and porosities by Chen and Wang to check the fatigue behavior.

➢ *Abrasion resistance*

The Cantabro test, the loaded wheel wear disc and the surface wear test are most commonly used to check the wear resistance of porous cement. Fiber and latex were used by Dong et al. Investigate the wear resistance of cementitious adhesives [3]. High levels of resistance were observed with the combination of latex and fibers. Gaedicke et. al. to study the wear resistance of cement.

Pebble gravel exhibits low abrasion resistance due to poor bonding between aggregate and cement paste in perforated concrete. Also, the recycled aggregates proved to be abrasion resistant materials for concrete. In other studies, different types of rubber were used to make different concretes to test abrasive behavior. Fine crushed rubber (mm and tire chips and crushed rubber reduced abrasion resistance.

➢ *Freeze-thaw studies*

Expanded concrete is usually stored in pores due to the macro-porous structure of the water, and porous concrete can undergo F-T cycles, causing the material to degrade. Losses that occur after several successive freezing and thawing cycles are commonly used to test F-T resistance. Different additives were being used to by researchers to measure the F–T resistance. Air-entraining admixture was used by Ghafoori and Dutta to improve F–T resistance in concrete [3]. Yang and Jiang found that silica smoke used in conjunction with super plasticizers increases F-T resistance. F–T resistance was also improved with the use of Tire chips and crumbed rubber. The fine rubber particles played the role of entrained air bubbles which increased air content, thereby reduction in the effect of expansive stresses by water on the cement paste was observed.

➢ *Pore properties*

The porosity of a classic porous concrete ranges between 15-25% with a least of 15% as authorized by the National Ready Mix Concrete Association (NRMCA) [1] [4].

III. POROUS PAVEMENT: APPLICATIONS, ADVANTAGES, DRAWBACKS, IMPACT ON ENVIRONMENT AND MAINTENANCE

A. Applications

- *Strom water management*-Porous pavements manage storm water, as the direct discharge generated by the urban roads and highways penetrates into the pavement through its pores. This storm water is stored into the voids of the porous pavement and slowly keeps moving into the soil below the pavement [6].
- *Restoring ground water supplies*-As the excess water penetrates into the porous pavement through its pore structure, later on this water goes to the soil which is present under the porous pavement to recharge the ground water [6].
- *Reducing water and soil pollution*-Porous pavement has different layers when observed through its cross- sectional view. When the water travels through these layers it gets filtered by the various layers of pavement such as base and sub base reservoir, thereby reducing the water and soil pollution.
- *Reduce urban heat islands*-Urban heat island is a phenomenon in which the impervious pavement systems behave as a heat storing media and these pavements release this heat back to the environment during night. As the name suggests porous pavement is a pervious pavement which don't stockpile heat and therefore reduces the urban heat islands [7].
- *Driveways* –Porous pavements are generally used in driveways where there is low traffic.
- *Parking lots* –The use of porous pavements in parking lots can be seen very easily in different malls, hospitals, MNCs and many other complex buildings.
- *Sidewalks* –Porous pavements are also seen on the sidewalks which allow the water to penetrate into the surface and keep the sidewalks slip free and clean.

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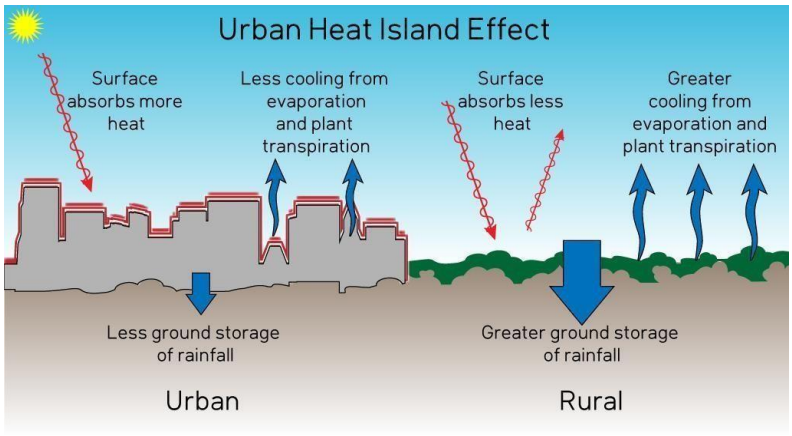

Fig. 2: Urban heat island diagram [8]

B. Advantages

- *Water purification*-As I have already discussed the cross-sectional view of the porous pavement so from that we can see that porous pavement purifies theexcess water and rain water which is being stored in it by the different layers of gravels ad pebbles [7].
- *Aesthetics*-There are various types of porous pavements available like as porous pavers, concrete pavers and asphalt pavers. These different types of pavements give high aesthetics to our building.
- *Design Flexibility*-We can design different types of porous pavements as per our needs and requirements. They provide great design flexibility to the designer. Porous pavements can be of different shapes, sizes and color as per our needs.
- *Nearby trees and plants are benefited*-When the water penetrates into the soil through porous pavements the nearby soil gets good amount of moisture which later on benefit the nearby plants of that area [10].
- *Sound absorption*-As the porous pavement is a gap graded material so it has large volume of joined voids or pores in it which makes it highly productive in acoustic absorption [7].

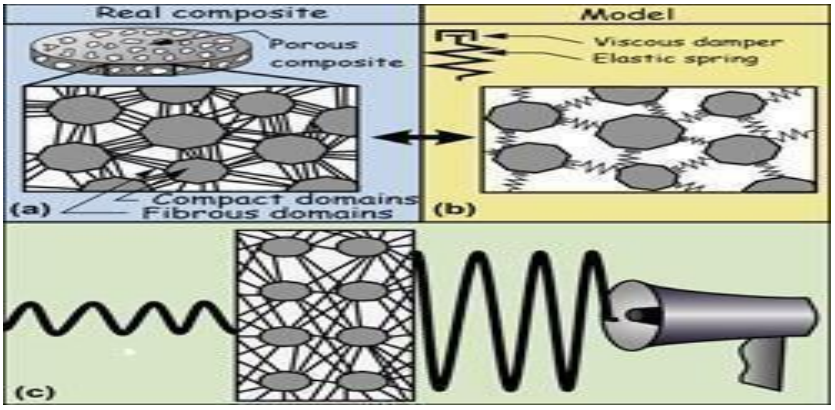

Fig. 3: Sound absorption [11]

- *Skid resistance*-The micro pores structure of the porous pavement checks the skid resistance at low velocity; on the other hand its macro pore structure simulates it at high velocity [7].

C. Drawbacks

- *Low strength and durability*-Due to presence of large number of interconnected voids in the structure of porous pavement, it shows low strength and is less durable [9].
- *Potential for clogging of porous media*-Due to presence of pores in the porous pavement structure, many things go and clog in the voids of the pavement making it less durable [4].
- *Not applicable for high-traffic areas*-As the porous pavement is less durable and have low strength so it cannot be used in high traffic areas [9].
- *Not applicable for use by heavy vehicles*-Due to its low strength, porous pavement cannot bear the load of heavy vehicles so it is not applicable for the use of large and heavy duty vehicles.
- *Difficulty in maintenance*-Due to its porous structure it is very hard to maintain this pavement as it gets clogged by different materials so it needs high attention for its maintenance [4].

D. Impact on environment

Trueman et al. [10] in the Conducting studies on soil close to plants and the influence of permeablepavement and soil moisture, soil temperature, growth and nutrient status of registered trees. Soil type and soildepth are then important factors in the influence of plants on the environment. A sidewalk that can be cleaned with a layer of deep foundation that connects the cobblestones and the floor can be very useful for low areas. This is due to the low porosity of the soil, which contributes to the accumulation of water in the base layer, and the depth of the base layer increases its ability to retain water and stops the absorption of waterunder the soil. Construction of a 300 mm thick conductive pavement on clay soils increased the diameter of tree trunks by 55% compared to treesplanted on conventional asphalt. The concentration of potassium in the leaves of the tree has doubled with this pavement design. This shows that properly designed waterproof sidewalks can improve the growth and health of street trees (2015).

E. Maintenance

Owing to the porous structure of the perviouspavement, it is important to periodically maintain the pavement, as it gets clogged. Therefore these pavements need proper cleaning and maintenance. Perodes et.al. [12] gave vacuuming, blowing and pressure washing are the three methods which are mainly used for cleaning of the PC pavements. Nowadays, washing machines, high pressure washers and their combination are used as road maintenance. Cleaning leads to more regeneration than a flush rinse and thinks of the most effective wayto combine the twomethods [13].

IV. CONCLUSION

With the urban surface evolution, it is expected that in the coming years permeable pavements will be used more and more taking us from the grey infrastructure to the green infrastructure. A large number of benefits are provided by the porous pavements such as storm water management, reduction in urban heat islands, improving the ground water and air quality, and many more. The US Environmental Protection Agency (USPA) has identified permeable asphalt as a "cold asphalt" that can be used to reduce urban warming on the island.

Slightly backwards, significant sections of vulnerable floor use are carved on areas with low vehicle load and /or traffic volume, such as sidewalks, parking lots, and living areas. However, in the near future, with the development of paving technology and the addition of strict environmental standards such as the replacement of cement with ash, coal and fine waste, the pavement is expected to be strong enough to be used in the city streets and roads.

REFERENCES

[1.] Ramadhansyah, P.J., Mohd Ibrahim, M.Y., Mohd Rosli, H. and Wan Ibrahim, M.H., 2014. A review of porous concrete pavement: applications and engineering properties. In Applied Mechanics and Materials (Vol. 554, pp. 37-41). Trans Tech Publications Ltd.

[2.] Kayhanian, M., Li, H., Harvey, J.T. and Liang, X., 2019. Application of permeable pavements in highways for stormwater runoff management and pollution prevention: California research experiences. International Journal of Transportation Science and Technology, 8(4), pp.358-372.

[3.] Chandrappa, A.K. and Biligiri, K.P., 2016. Pervious concrete as a sustainable pavement material–Research findings and future prospects: A state-of-the-art review. Construction and Building Materials, 111, pp.262-274.

[4.] https://encryptedtbn0.gstatic.com/images?q=tbn%3AANd9GcQvD5BV9vWOc6n89zG-9_E7bBtP4CJoll-cNQ&usqp=CAU

[5.] Xu, G., Shen, W., Huo, X., Yang, Z., Wang, J., Zhang, W. and Ji, X., 2018. Investigation on the properties of porous concrete as road base material. *Construction and BuildingMaterials*, *158*, pp.141-148.

[6.] Chu, L., Tang, B. and Fwa, T.F., 2018. Evaluation of functional characteristics of laboratory mix design of porous pavement materials. *Construction and Building Materials*, *191*, pp.281-289.

[7.] Elizondo-Martinez, E.J., Andrés-Valeri, V.C., Jato-Espino, D. and Rodriguez-Hernandez, J., 2020. Review of porous concrete as multifunctional and sustainable pavement. Journal of Building Engineering, 27, p.100967.

[8.] https://www.skepticalscience.com/graphics/UrbanHeatIsland.jpg

[9.] Opiso, E.M., Supremo, R.P. and Perodes, J.R., 2019. Effects of coal fly ash and fine sawdust on the performance of pervious concrete. *Heliyon*, *5*(11), p.e02783.

[10.] Mullaney, J., Lucke, T. and Trueman, S.J., 2015. The effect of permeable pavements with an underlying base layer on the growth and nutrient status of urban trees. Urban Forestry & Urban Greening, 14(1), pp.19-29.

[11.] https://static.cambridge.org/content/id/urn%3Acambridge.org%3Aid%3Aarticle%3AS0884291413001945/resource/name/S0884291413001945_figAb.jpeg?pub-status=live

[12.] Hu, N., Zhang, J., Xia, S., Han, R., Dai, Z., She, R., Cui, X. and Meng, B., 2020. A field performance evaluation of the periodic maintenance for pervious concrete pavement. Journal of Cleaner Production, p.121463.

[13.] Saadeh, S., Ralla, A., Al-Zubi, Y., Wu, R. and Harvey, J., 2019. Application of fully permeable pavements as a sustainable approach for mitigation of stormwater runoff. *International Journal of Transportation Science and Technology*, *8*(4), pp.338-350.